water for life

reliable, quality water supplies
for a sustainable economy

summary report: water supply assessment for alberta

> prepared for: Alberta Environment
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> june 2009

Alberta

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Summary Report:

Water Supply Assessment for Alberta

Alberta Environment

June 2009

Government of Alberta
Environment

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Background

The Alberta *Water for Life* Strategy was developed to ensure Albertans have safe, secure drinking water, healthy aquatic ecosystems, and reliable water supplies of suitable quality for a sustainable economy. Following a recent study of current and future water use in the province (AENV, 2007), Alberta Environment (AENV) commissioned a report to assess the baseline water supply in all major basins in Alberta. The purpose of the "Water Supply Assessment for Alberta" (AENV, 2009) is to summarize understanding of the current water supply (or water yield) through an analysis of existing records of streamflow data and other climate information. Understanding both supply and demand helps to begin to define measures of "reliability" – one key indicator being the potential gap between water demand and water supply in different areas and at different times. Two types of source water yield are addressed: surface water and groundwater.

Major basins included in the Assessment:

Milk River Basin • Oldman River Basin • Bow River Basin • South Saskatchewan River Basin • Red Deer River Basin • Battle River Basin (incl. Sounding Creek Basin) • North Saskatchewan River Basin • Beaver River Basin • Athabasca River Basin • Peace / Slave River Basin • Hay River Basin • Liard River Basin

One of the principal outcomes of *Water for Life* is **"Reliable, quality water supplies for a sustainable economy"**. This outcome has an intuitive meaning and most people would have a concept of what it means. In practice, defining the terms of success and providing practical measures to assure that Alberta is achieving its outcomes requires additional thought. Based on discussions at the project kick-off meeting, it appears that a definition of "reliable, quality water supplies" should include the following as a minimum:

- Dependability, meaning that water is available at the time and in the amounts required when it is needed most;
- Sustainability, for now and future generations and for the future growth of the province;
- Suitability for all practical uses;
- Maintenance of the health of aquatic ecosystems and environmental sustainability; and,
- A water supply that is well understood, is wisely managed, is protected from quantity and quality impacts, and can be passed on with suitable quantity and quality to our downstream neighbours.

Quantification of "dependability", "sustainability", "suitability", and "healthy aquatic ecosystem" is clearly very difficult and requires further conversations and multi-disciplinary input. At its most fundamental level, water management can be described using two basic concepts: supply and demand. The notion of having those two things being in balance would seem to form a basic tenet of "reliability" providing assurance that sufficient water supplies are available under most, if not all, conceivable conditions. When one side of the equation is out of balance, over the long-term it would be necessary to either increase supply, reduce demand, or some combination of the two.

The full report (AENV, 2009) presents detailed water yield information and the water supply-demand conditions for the twelve major basins identified in the previously completed water demand study (AENV, 2007). By using a consistent provincial approach and summarizing results by river basin it is hoped that others, such as Watershed Planning and Advisory Councils (WPACs), can take these results and further develop the analyses at a regional or sub-basin level as needed. It also demonstrates a commitment within *Water for Life* to develop and provide water knowledge to further inform Albertans on the state of the resource. A second

objective of this project was to scope out a path for assessing the potential effects of climate change on future water yield. The main outcome was a two-day workshop that involved specialists in the fields of climate change and hydrology along with government managers and staff as well as one WPAC. The results of the workshop and considerations for approaching future climate change assessment work are included in the full report.

Approach

The principal approach for assessing water yield was to subdivide the province into hydrologic regions. A hydrologic region is a zone or area where similar hydrologic patterns can be observed – in particular the timing and amount of runoff that is expected. For example: catchment response to precipitation or storm events, seasonal flows, and overall annual water yield. Determining the different hydrologic regions was based on multiple considerations:

- climate (similar precipitation patterns of both rain and snow; evaporation);
- topography (the "lay of the land" – terrain type, slope, elevation, aspect);
- drainage (slope, channels and surface patterns of runoff);
- soils (types – poorly or well drained; composition – sands, clay, loam, etc.);
- geology (underlying rock and formations influencing recharge/discharge); and
- vegetation (types of vegetative cover for an area are typical indicators of hydrologic conditions and vice versa).

For each streamflow station, the average annual runoff (annual yield) and average monthly runoff (monthly yield) were calculated based on the available data. Other statistical information was computed so that variability and extremes – both from season to season and year to year – were mathematically described. The surface water yield assessment involved the

characterization of natural average water yields as well as their variability (what are the typical ranges) and extremes (maximums and minimums) in the twelve basins. Summary yield estimates from each of the twelve basins (plus two sub-basins) are provided in the following Table:

Summary of Mean Annual Basin Yield (millions of cubic metres)

Bow River Basin	4,060	North Saskatchewan River Basin	7,530
Oldman River Basin [1]	3,540	Beaver River Basin	599
Red Deer River Basin	1,960	Athabasca River Basin [5]	23,500
Lower South Saskatchewan Basin	100	Peace River Basin [6]	70,200
South Saskatchewan River Basin [2]	9,660	Slave River Basin [7]	112,000
Milk River Basin [3]	196	Hay River Basin [8]	3,510
Battle River Basin [4]	293	Liard River Basin [9]	960

Notes:

1. Oldman River Basin yield includes 1,050 Mm^3 (30% of total yield) of water from St. Mary River from the United States (Montana).

2. South Saskatchewan River Basin yield includes Oldman River Basin (37% of total yield), Bow River Basin (42% of total yield) and Red Deer River Basin (20% of total yield).

3. Milk River Basin yield includes 130 Mm^3 (66% of total yield) of water from the United States (Montana). Milk River Basin includes Pakowki Lake Basin, which is a non-spilling drainage basin (does not flow to downstream).

4. Battle River Basin includes Sounding Lake Basin, which spills to downstream only during wet climate cycles. Battle River Basin yield is not included in the North Saskatchewan River Basin total. (The Battle River does eventually join the North Saskatchewan River downstream in Saskatchewan.)

5. Athabasca River Basin yield includes 2,850 Mm^3 (12% of total yield) from Saskatchewan.

6. Peace River Basin yield includes 51,490 Mm^3 (73% of total yield) from British Columbia.

7. Slave River Basin yield includes Peace River Basin (63% of total yield), 14,600 Mm^3 (13% of total yield) from Lake Athabasca Basin including areas upstream in Saskatchewan, Athabasca River Basin (21% of total yield), as well as contributions from the Buffalo/Great Slave basins in Alberta although they do not drain directly to the Slave River but flow north to Northwest Territories.

8. Hay River Basin yield includes 627 Mm^3 (18% of total yield) from British Columbia.

9. Liard River Basin yield includes 161 Mm^3 (17% of total yield) from Northwest Territories.

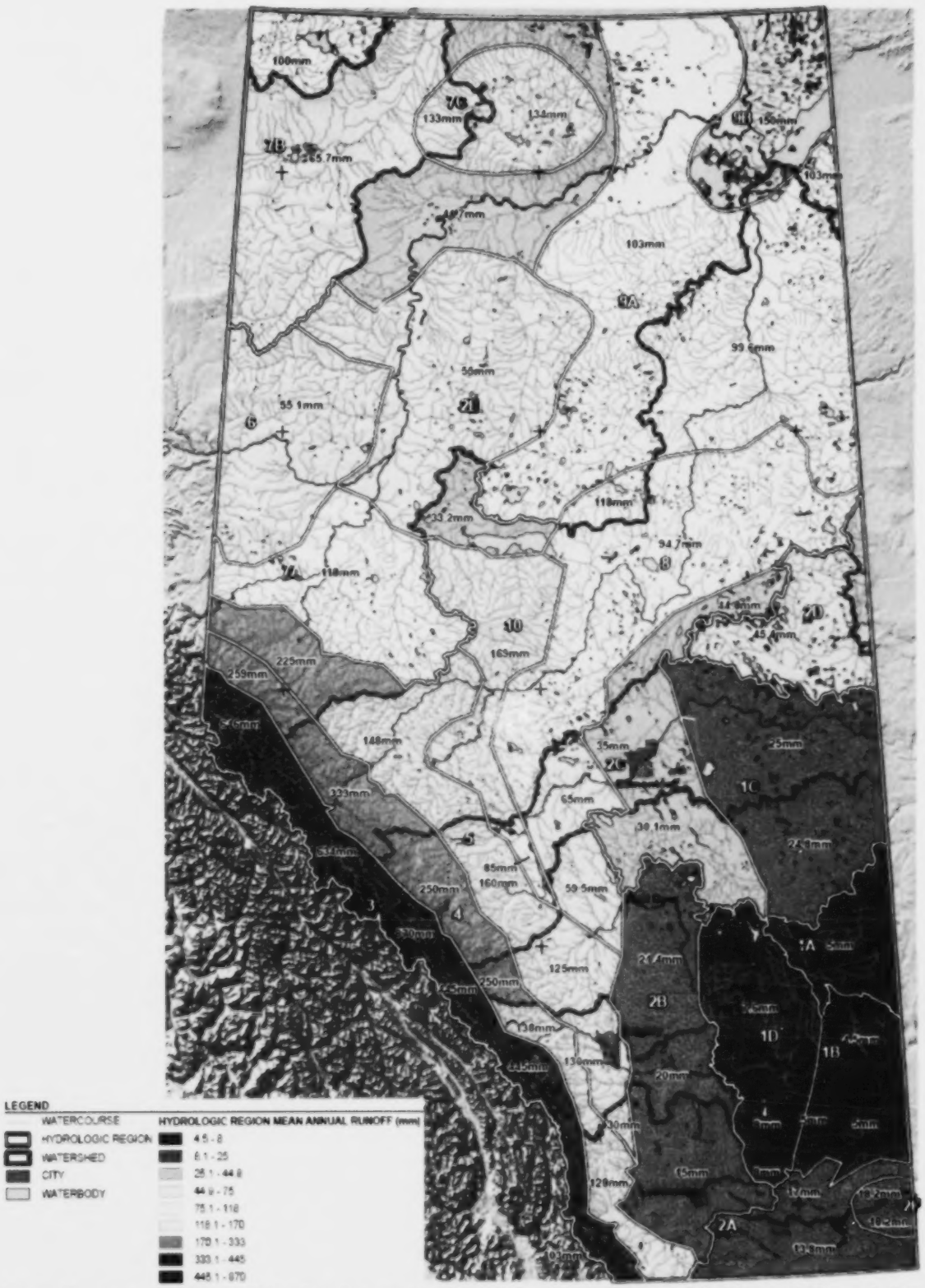
It is important to remember that these numbers are only long-term averages. The hydrology of Alberta is much more variable than these single numbers can describe. "Average" in the context of prairie climate is sometimes described as being just an average of years that are either "wet" or "dry" – and there is some truth to this. As an example the largest rivers that are fed by mountain snowmelt tend to have more reliable flows, with "dry" being around one-half or two-thirds of the average and "wet" being approximately double the average flow. In other words, a wet year has three to four times the flow of a dry year. As you move to smaller, prairie-fed rivers the difference in flow between a wet year and a dry year can easily reach a factor of ten. Smaller creeks may flow hardly at all in dry years or will stop flowing after the spring runoff unless it rains significantly. Planning for such inherent natural variability in water supply is a challenge.

Climate and Water

The numbers presented for average basin water yields are large and probably difficult to visualize. Even so, surface runoff is only a relatively small part of the hydrologic cycle in Alberta. Alberta is a semi-arid, continental climate – meaning that average lake evaporation and evapotranspiration demands (from plants and soil) are higher than the average precipitation that occurs over most areas of the province. Of the roughly 337,000 million m^3 of water that would fall over Alberta as rain and snow on average, up to 82% returns to the atmosphere from evaporation and transpiration from vegetation. This leaves only 18% – about 61,000 million m^3 – to both recharge the groundwater and also generate the surface runoff that appears in creeks, rivers, lakes and wetlands within Alberta's borders.

A further key highlight of this report is the role of mountains and high alpine landscapes as the primary source of water for Alberta and the prairies. All of Alberta's largest rivers – Peace, Smoky, Athabasca, North Saskatchewan, Bow, Oldman – have their origin in the Rocky Mountains at the highest elevations along the continental divide. The accumulation of annual snowpack in the mountains and the resulting snowmelt is the single largest supply of water for the province. This is illustrated by the maps showing the progression of accumulated runoff

across each of the basins. Most of these rivers have accumulated the majority of their flow (from three-quarters to more than 90% in some cases) by the time they leave the foothills. Figure 3.3 from the report describes why this is case: a unit area of land in the high mountains can be 200 to 300 times as productive in terms of average annual runoff yield than the same unit area in the much drier, south-eastern prairie areas of Alberta.



From the report: Figure 3.3 showing general hydrologic regions of Alberta and the relative amount of water each region yields on an average annual basis (blue is wetter, brown is drier).

Groundwater

The groundwater resource in Alberta is in total very large but only a small portion is recoverable by wells in sufficient quantity and suitable quality for general use. Groundwater is more difficult to quantify because it can't be "seen" or measured in the same way that surface water can. As a result, specific knowledge of groundwater resources in Alberta (where and how much) is not as extensive – though there is a lot of general expertise and local knowledge. There are some basic approaches that can be used to try and estimate the amount of water that travels or is recycled through the hydrologic cycle on an average annual basis. Groundwater is a much slower process than surface and near-surface flows, and water can reside and travel through aquifers for years, decades, centuries or even longer. Even so, there is a certain amount that will go into (recharge) and come out of (discharge) longer-term storage each year, appearing as baseflow in rivers and streams and lakes.

The groundwater assessment in the report is based on elementary estimates of recharge, discharge, and sustainable groundwater yield. Two approaches were used: the first method was based on the mathematical separation of the baseflow component from average annual hydrographs at streamflow monitoring stations in selected basins. In the second approach, the Alberta Agriculture map entitled "Aquifer Vulnerability Index Map for Agricultural Areas of Alberta" and the Energy Resources Conservation Board/Alberta Geological Survey map entitled "Natural Suitability of Geological Setting for Waste Management, Alberta, Canada" were adapted to estimate recharge. Infiltration and recharge rates through the soils and soil layers were derived for the areas mapped to calculate total annual recharge for each geological unit, and these were summed up for the total river basin.

Conservation and long-term sustainability of the groundwater resource is a primary management objective for Alberta Environment, however an official definition of *sustainable*

groundwater yield has not been defined in legislation or regulation. For the purposes of this study, the sustainable groundwater yield was considered to be 15 percent of the difference between total open-water baseflow and the total (over eight months) ecological portion of open-water baseflow equivalent to the 20th percentile of the average of the winter monthly mean flows. This is somewhat analogous to instream flow methods for surface waters, in recognition that groundwater and surface water are ultimately interconnected as a single resource.

Using the baseflow separation approach, the winter baseflow volume province-wide is estimated to be about 4.8 billion m^3. Streamflow measured during the winter months is often used as an estimate for baseflow since most surface water and the hydrologic cycle is otherwise frozen and assumed to be non-contributing. Winter baseflow volume is then extrapolated into a 12-month volume to generate an annual average quantity – about 14.6 billion m^3. Further accounting for increases in baseflow during the open-water season (when spring runoff and summer rains add to groundwater recharge and discharge rates) results in an average annual baseflow volume of about 25 billion m^3 province-wide. The second method using interpretation of surface geology maps and estimating the recharge potential of soils and surficial layers results in a total groundwater recharge volume for Alberta of about 27.1 billion m^3 per year. Note that definitions of baseflow and baseflow separation techniques are varied and subjective. Nonetheless, the different approaches taken to date suggest a range of mean provincial groundwater recharge would be between 15 and 30 billion m^3 per year. Put into perspective, that means between 25 and 45% of all the renewable surface water that is generated annually in Alberta comes from groundwater discharge. Using the previously-explained method for estimating sustainability, the sustainable annual groundwater yield province-wide would be approximately 1.9 billion m^3.

How much is 1.9 billion m³?

- ✓ *Provides 523,000 L of water for each of Alberta's 3.6 million citizens. The average Edmontonian uses around 88,000 L of water per year, just below the Canadian national average for residential use.*
- ✓ *Is enough to provide nearly 15 years of water supply for the Edmonton Capital Region.*
- ✓ *If you measured the flow of the Red Deer River for a whole year, every year – over the long-term, that is the average amount of water that would flow by annually.*
- ✓ *Is enough water to supply the average annual water needs of the five largest of Alberta's 13 Irrigation Districts.*
- ✓ *Spread over the area of Calgary or Edmonton the water would be 2.7 m (8.8 ft.) deep. The same volume of water poured over the whole area of Alberta would produce a puddle 3 mm (1/9 of an inch) deep.*

Climate Change

Though there are significant differences in results across individual models, most of the climate change predictions (general circulation models) have tended to predict warmer temperatures in the coming century for Alberta, along with a negligible to slight increase in the average annual precipitation. Because of the hydrologic feedbacks and significant variability – not only season to season, year to year, and place to place – it is not immediately apparent what the impact of increasing temperatures and slightly increasing precipitation totals will mean for the prairies. Results from recent studies seem to suggest that overall the prairies are likely going to become more arid. This is explained by a couple key factors:

- Though evaporation and evapotranspiration rates may not increase much, warmer temperatures increase the length of the growing seasons allowing more water to go back to the atmosphere through plants and soils;
- An increasing mix of rain at the expense of snow and snowpack; rainfall tends to produce less runoff than an equivalent amount of snowmelt or spring runoff.

For the purposes of the water demand-supply assessment, it was conservatively assumed that the mean annual water yield from all basins in Alberta would decrease by 10% in the near future. This figure is based on studies done for some areas of the province, which on average tend to come up with impacts of around that magnitude (recognizing that there are predictions of a range of impacts). Graphics depicting the new supply-demand conditions under the assumed future water yield conditions were created.

Putting It All Together

Using data on water usage compiled as part of a water use and demand study (AENV, 2007) and the results of the water yield analysis carried out for this study, graphics depicting existing and possible future (2025) water supply-demand conditions were created for each of the twelve basins of Alberta. The water demand accounting included consideration of apportionment of water at the Canada-United States border and Alberta-Saskatchewan boundary. In addition to human needs, a principal "demand" on the natural flow regime is for providing instream flow needs (IFN) – in this case the environmental flows that ensure that the ecological integrity and functioning of ecosystems are maintained. IFNs have not yet been established formally for all major river systems in the province. The IFN values used in this report are based on the most recent (and most protective) science-based desktop methodology developed for Alberta. They are provided for discussion purposes only as they do not necessarily reflect current or proposed numbers for rivers in Alberta; nor do they necessarily reflect current regulatory requirements or management objectives.

The water supply-demand assessment identified the **Bow River Basin**, **Oldman River Basin**, **South Saskatchewan River Basin** and the **Milk River Basin** as having **existing or emerging constraints**, either because of instream flow needs, apportionment needs, dry hydrologic years, increases in future demand or effects of climate change on water yield. The analysis was based

on average annual and monthly yields at the most downstream location of each basin within Alberta and the licensed annual water allocations. The assessment based on *seasonal yield* identified the **North Saskatchewan River Basin** and **Battle River Basin** as additional basins that show water supply-demand **constraints during certain times of the year**. The report recommended that these six basins be given priority for more detailed water yield and demand analyses and for climate change studies to assess the water supply-demand conditions at upstream locations in the basins and on at least a seasonal or monthly time frame. The role of storage and flow regulation introduces additional complexity into the systems and needs to be further incorporated since it provides a buffer from the variability in natural supply that would otherwise be experienced.

Table 6.2 from the report (next page) summarizes the key data for each basin, providing a snapshot of the current amount of water allocation and use as well as approximate numbers for apportionment demands and hypothetical instream flow needs (assuming the same method was applied to all basins for the purposes of comparison). These data are compared to the assessment of average water supply that is available.

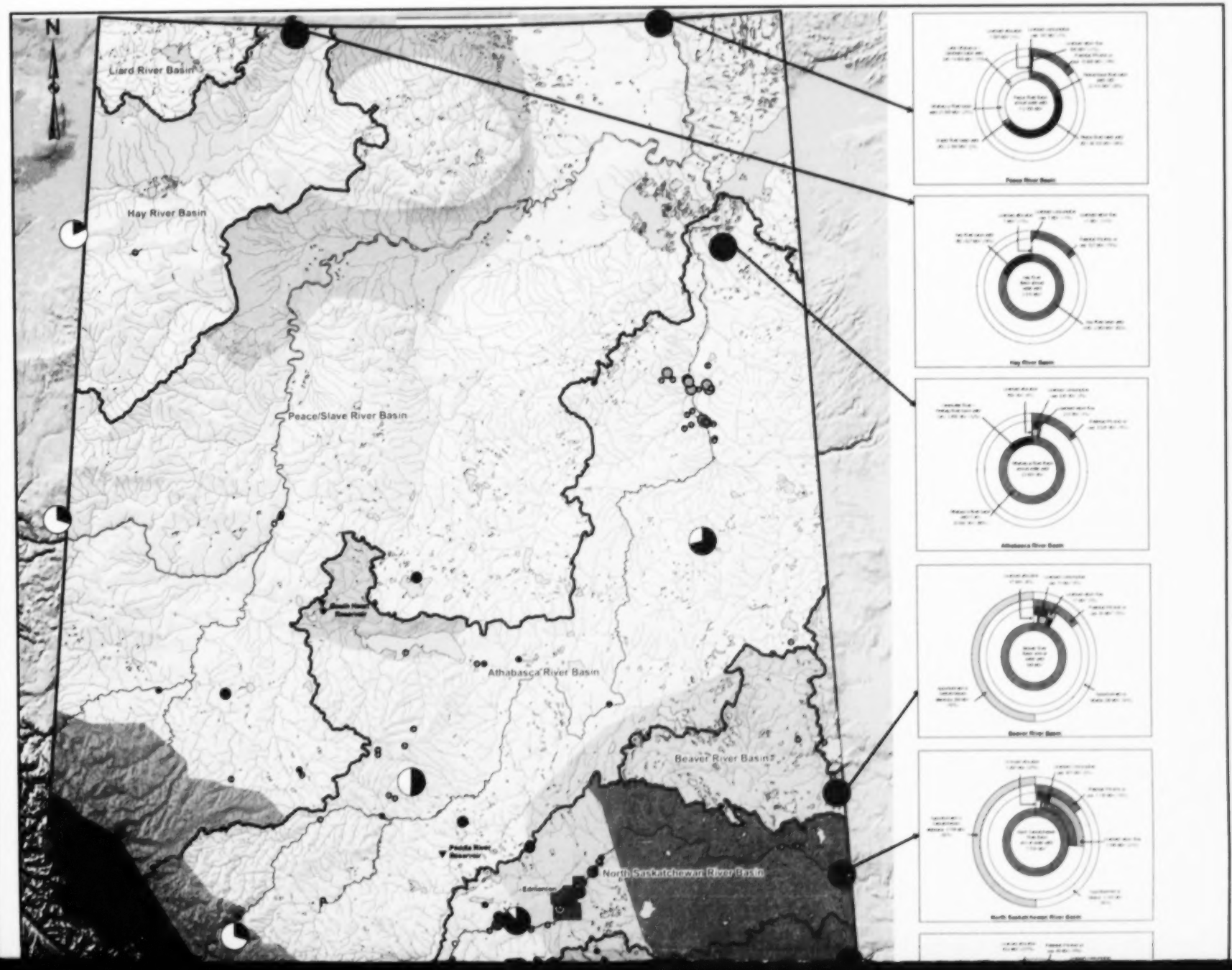
Figure 7 from the report follows Table 6.2; it shows in map form the data that is presented in the table. The figure provides a visual comparison, at-a-glance, for all the major basins in Alberta. The supply-demand relationships are presented in the "ring" diagrams. **The innermost ring describes the total supply and where it comes from; the next two rings describe the allocations along with a sector breakdown; the final two rings show the hypothetical "IFN" (presuming all basins equal) and any apportionment considerations.** An overview of each basin makes up the remainder of the report, with a more detailed map and individual discussion with some of the highlights presented for each.

Table 6.2 – Summary of Current Annual Basin Water Yield and Demand

	Bow River Basin		Oldman River Basin		Red Deer River Basin		South Saskatchewan River Basin		South Saskatchewan River Basin - Downstream		Milk River Basin		Battle River Basin		North Saskatchewan River Basin		Beaver River Basin		Athabasca River Basin		Peace/Slave/Athabasca River Basin		Hay River Basin	
	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)	(Mm^3)	(%)
Basin water yield	**4,060**	**100%**	**3,540**	**100%**	**1,960**	**100%**	**7,700**	**100%**	**9,660**	**100%**	**196**	**100%**	**293**	**100%**	**7,530**	**100%**	**599**	**100%**	**23,500**	**100%**	**112,000**	**100%**	**3,510**	**100%**
Licensed Allocation	**2,598**	**64%**	**2,292**	**65%**	**373**	**19%**	**5,172**	**67%**	**5,545**	**57%**	**62**	**32%**	**812**	**277%**	**1,997**	**27%**	**47**	**7.9%**	**850**	**3.6%**	**1,093**	**1.0%**	**6.6**	**0.2%**
Municipal	500	12%	64	1.8%	69	3.5%	734	10%	804	8%	2.5	1%	22	7%	164	2.2%	12	2.0%	46	0.2%	73	0.1%	0.7	0.0%
Agriculture	1,987	49%	1,999	56%	107	5.5%	4,061	53%	4,169	43%	55	28%	34	12%	26	0.3%	2.2	0.4%	13	0.1%	22	0.0%	0.0	0.0%
Commercial	36	0.9%	14	0.4%	10	0.5%	52	0.7%	62	0.6%	0.8	0.4%	2.7	0.9%	16	0.2%	0.3	0.1%	3.8	0.0%	7.2	0.0%	0.0	0.0%
Petroleum	10	0.2%	4.3	0.1%	49	2.5%	21	0.3%	70	0.7%	-	0.0%	10	3.4%	93	1.2%	21	3.5%	582	2.5%	602	0.5%	4.9	0.1%
Industrial	34	0.8%	0.0	0.0%	22	1.1%	54	0.7%	76	0.8%	-	0.0%	692	236%	1,661	22%	0.0	0.0%	145	0.6%	236	0.2%	-	0.0%
Other	31	0.8%	211	6.0%	115	5.8%	250	3.3%	365	3.8%	4.3	2.2%	51	18%	36	0.5%	12	2.0%	60	0.3%	152	0.1%	1.0	0.0%
Licensed water source																								
Surface water	2,561	63%	2,231	63%	335	17%	5,071	66%	5,406	56%	61	31%	787	269%	1,971	26%	33	5.5%	760	3.2%	227	0.2%	5.9	0.2%
Ground water	37	0.9%	61	1.7%	37	1.9%	102	1.3%	139	1.4%	1.4	0.7%	24	8.3%	25	0.3%	14	2.4%	89	0.4%	17	0.0%	0.7	0.0%
Licensed water destination																								
Consumptive use	2,030	50%	2,055	58%	268	14%	4,291	56%	4,558	47%	60	31%	111	38%	401	5.3%	31	5.2%	636	2.7%	787	0.7%	6.5	0.2%
Return flow	568	14%	237	6.7%	105	5.4%	881	11%	986	10%	2.4	1.2%	700	239%	1,596	21%	17	2.8%	214	0.9%	306	0.3%	0.1	0.0%
Water use (i.e. not greater than licensed)																								
Estimated 2005	1,152	28%	1,141	32%	223	11%	2,359	31%	2,582	27%	55	28%	80	27%	196	2.6%	18	2.9%	273	1.2%	118	0.1%	3.2	0.1%
Projected 2025	1,354	33%	1,254	35%	250	13%	2,677	35%	2,927	30%	59	30%	105	36%	263	3.5%	14	2.4%	512	2.2%	143	0.1%	2.4	0.1%
Potential IFN limit on use	**609**	**15%**	**531**	**15%**	**294**	**15%**	**1,155**	**15%**	**1,449**	**15%**	**29**	**15%**	**44**	**15%**	**1,130**	**15%**	**90**	**15%**	**3,525**	**15%**	**16,800**	**15%**	**527**	**15%**
Apportionment to Canada			3,110	88%							72	37%												
Apportionment to Alberta					980	50%	3,635	47%	4,615	48%	62	32%	147	50%	3,765	50%	300	50%						
Apportionment to Saskatchewan/ Manitoba					980	50%	3,635	47%	4,615	48%	10	5%	147	50%	3,765	50%	300	50%						
Apportionment to U.S.			431	12%			431	6%	431	4%	124	63%												

Notes:

1 Percentages are based on the total basin water yield
2 Oldman River Basin yield includes 1,050 Mm^3 (30% of total yield) of water from St. Mary River from the U.S.
3 Milk River Basin yield includes 130 Mm^3 (66% of total yield) of water from the U.S.
4 South Saskatchewan River Basin includes Oldman River and Bow River basins.
5 South Saskatchewan River Basin - downstream includes Oldman River, Bow River and Red Deer River basins.
6 Athabasca River Basin yield includes 2,850 Mm^3 (12% of total yield) from Saskatchewan.
7 Peace/Slave/Athabasca River Basin yield includes 51,490 Mm^3 (46% of total yield) from British Columbia, 14,600 Mm^3 (13% of total yield) from Lake Athabasca + its upstream area from Saskatchewan, and Athabasca River Basin yield. Contribution from Peace River is about 70 Mm^3. See Figure 5 in Appendix 10 Peace-Slave Rivers.
8 Hay River Basin yield includes 627 Mm^3 (18% of total yield) from British Columbia.
9 Liard River Basin data is not included in this table. Water demand data not available.


N
Liard River Basin
Hay River Basin
Peace/Slave River Basin
Athabasca River Basin
Beaver River Basin
North Saskatchewan River Basin
Edmonton

North Saskatchewan River Basin
Battle River Basin
Red Deer River Basin
Bow River Basin
Oldman River Basin
South Saskatchewan River Basin
Milk River Basin
Athabasca River Basin
Red Deer River Basin
Bow River Basin
Supply Demand
User Key
1 Total water used from various sources
2 Licensed allocations: municipal, agriculture, commercial, petroleum, industrial, and other
3 Licensed consumptive use and return flow
4 Potential EIs (not on use)
5 Apportionment of water to various provinces and U.S.

LEGEND

WATERCOURSE
WATERSHED
CITY
WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³
- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

WATERSHED WATER YIELD (mm)

- UNDEFINED
- 4.5 - 8.0
- 13.6 - 25.0
- 30.1 - 45.4
- 55.0 - 65.7
- 85.0 - 118.0
- 125.0 - 170.0
- 225.0 - 333.0
- 403.0 - 445.0
- 634.0 - 870.0

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (1944 TO 1999) MEASURED WITH THE 10 MOST DOWNSTREAM LOCATIONS

REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license.
Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

125 0 125
SCALE 1:2,000,000 KILOMETRES

PROJECT
WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE
WATER SUPPLY AND DEMANDS FOR BASINS IN ALBERTA

Golder Associates
Calgary, Alberta

PROJECT No. 07-1326-0021			SCALE AS SHOWN	REV. 0
DESIGN	VC	10 Apr 2008	FIGURE: 7	
GIS	AC	08 Jul 2008		
CHECK	AB	23 Jul 2008		
REVIEW	AB	23 Jul 2008		

Milk River Basin

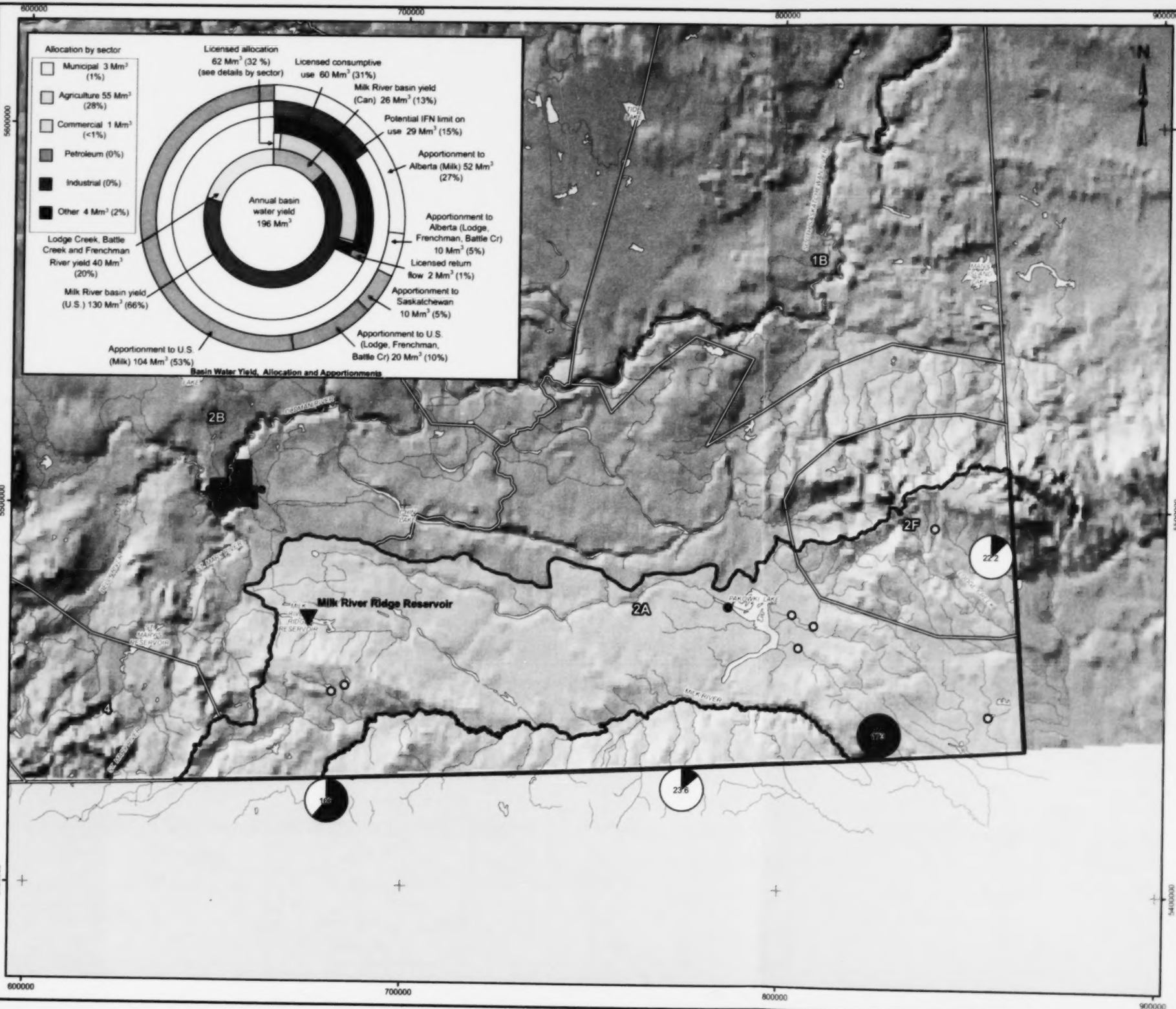
The Milk River Basin is composed of two major sub-basins. The Milk River mainstem originates in Montana and flows north-easterly into Alberta before flowing back south-easterly into Montana. The Milk River eventually flows into the Missouri and Mississippi Rivers, reaching the Gulf of Mexico. The second sub-basin is Pakowki Lake, which is geographically part of the Milk River Basin but water levels never reach high enough to flow downstream. The basin is referred to as a closed drainage or non-spilling basin. Water generated within this sub-watershed flows to Pakowki Lake where the lake evaporation roughly balances the inflows.

The majority of Milk River flow is produced in the Montana headwaters. Water in the Milk River and the neighbouring St. Mary River Basin are apportioned between Canada and the United States under the 1909 Boundary Waters Treaty. Montana receives a higher proportion of the Milk River in exchange for Canada receiving a higher proportion of the St. Mary River. Very roughly, about two-thirds of the Milk Basin waters are required for apportionment to either the United States (primarily) or Saskatchewan. Actual consumption (2005 data) amounted to approximately 28% of the basin supply.

Compared to the natural yield of the Milk River, the actual flows in the river are significantly higher than natural during summer. This is because of water the United States diverts from the St. Mary River to the Milk as part of their entitlement under the Boundary Waters Treaty. During the irrigation season, U.S. water from the St. Mary River is conveyed via canal to the Milk River where it then flows through to Montana and downstream. These augmented flows are not considered in the report as it does not reflect natural runoff and Alberta is not entitled to any portion of this conveyed water.

Allocation by sector
Municipal 3 Mm³ (1%)
Agriculture 55 Mm³ (28%)
Commercial 1 Mm³ (<1%)
Petroleum (0%)
Industrial (0%)
Other 4 Mm³ (2%)
Licensed allocation 62 Mm³ (32 %) (see details by sector)
Licensed consumptive use 60 Mm³ (31%)
Milk River basin yield (Can) 26 Mm³ (13%)
Potential IFN limit on use 29 Mm³ (15%)
Apportionment to Alberta (Milk) 52 Mm³ (27%)
Apportionment to Alberta (Lodge, Frenchman, Battle Cr) 10 Mm³ (5%)
Licensed return flow 2 Mm³ (1%)
Apportionment to Saskatchewan 10 Mm³ (5%)
Apportionment to U.S. (Lodge, Frenchman, Battle Cr) 20 Mm³ (10%)
Apportionment to U.S. (Milk) 104 Mm³ (53%)
Milk River basin yield (U.S.) 130 Mm³ (66%)
Lodge Creek, Battle Creek and Frenchman River yield 40 Mm³ (20%)
Annual basin water yield 196 Mm³

Basin Water Yield, Allocation and Apportionments



LEGEND

- MILK RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

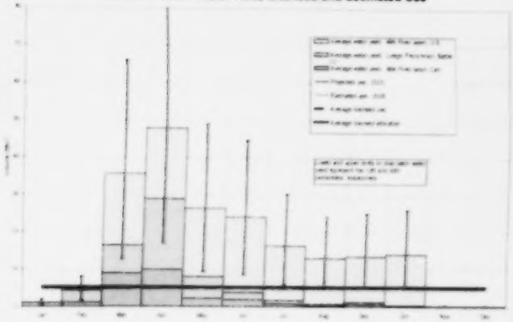
RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

40 0 40

SCALE 1:1,000,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

MILK RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO. 07-1328-0077			SCALE AS SHOWN	REV. 0
DESIGN	AB	13 Mar. 2008	**FIGURE: 6**
GIS	MB	07 Jul. 2008	
CHECK	AB	23 Jul. 2008	
REVIEW	AB	23 Jul. 2008	

Oldman River Basin

The Oldman River Basin includes the St. Mary River basin which has headwaters in the United States. The apportionment of the St. Mary and Milk Rivers between Canada and the United States is governed under the 1909 Boundary Waters Treaty. Canada receives a higher proportion of the St. Mary River in exchange for Montana receiving a higher proportion of the Milk River. The U.S.-apportioned quantity of the St. Mary River makes up a smaller but significant portion (about 12%) of the overall Oldman River Basin water yield, with the remaining supply coming from other large tributaries such as the Waterton-Belly, Castle, Crowsnest and upper Oldman Rivers. Lethbridge is the largest community in the basin with nearly 84,000 residents.

The estimated average basin supply for the Oldman is 3,540 million m^3. Based on the 2005 data licences totalling 2.3 billion m^3 or 65% of the estimated basin water supply have been allocated. Irrigation holds the majority of licensed water in the basin (86%). Surface water allocations are not increasing since new surface water licence applications are no longer being accepted in the Oldman River Basin. Actual consumption (2005 data) amounted to approximately one-third of the basin supply.

500000 600000 700000

5600000 5500000

ALBERTA INFRASTRUCTURE AND TRANSPORTATION

Lake McGregor S. Dam

ALBERTA ENVIRONMENT

Twin Valley Reservoir

Clear Lake

Travers Reservoir

Chain Lakes Reservoir

Pine Coulee Reservoir

Keho Lake

LETHBRIDGE NORTHERN IRRIGATION DISTRICT (X5)

ALBERTA ENVIRONMENT

Lethbridge

TABER IRRIGATION DISTRICT (X4)

RAYMOND IRRIGATION DISTRICT (X6)

ST. MARY RIVER IRRIGATION DISTRICT (X7)

MAGRATH IRRIGATION DISTRICT

St. Mary Reservoir

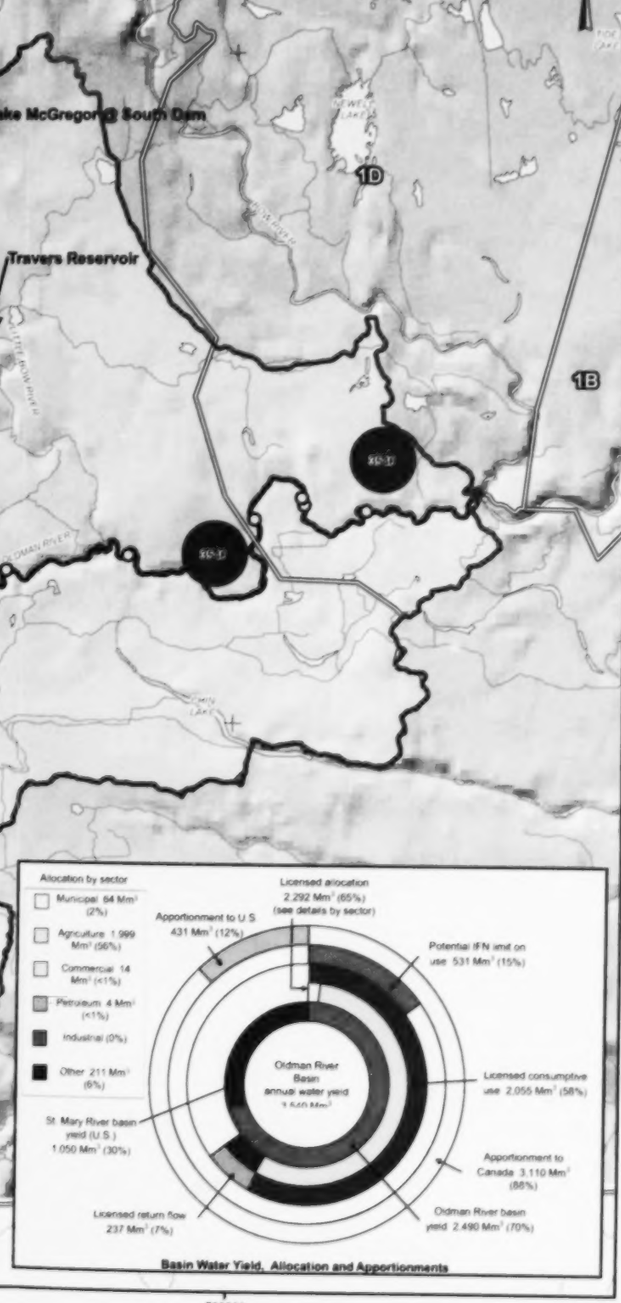
ALBERTA ENVIRONMENT

BLOOD INDIAN BAND COUNCIL

UNITED IRRIGATION DISTRICT (X2)

1050

1D 1B 2B 5 4 3


Allocation by sector
Municipal 64 Mm³ (2%)
Agriculture 1,999 Mm³ (56%)
Commercial 14 Mm³ (<1%)
Petroleum 4 Mm³ (<1%)
Industrial (0%)
Other 211 Mm³ (6%)
Licensed allocation 2,292 Mm³ (65%) (see details by sector)
Apportionment to U.S. 431 Mm³ (12%)
Potential IFN limit on use 531 Mm³ (15%)
Licensed consumptive use 2,055 Mm³ (58%)
Apportionment to Canada 3,110 Mm³ (88%)
Oldman River basin yield 2,490 Mm³ (70%)
Licensed return flow 237 Mm³ (7%)
St. Mary River basin yield (U.S.) 1,050 Mm³ (30%)
Oldman River Basin annual water yield

Basin Water Yield, Allocation and Apportionments

N

LEGEND

- OLDMAN RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

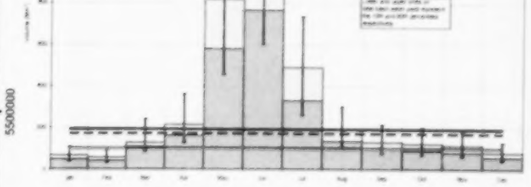
RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

30 0 30

SCALE 1:850,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

OLDMAN RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO. 07-1326-0021			SCALE AS SHOWN REV. 0
DESIGN	AB	13 Mar 2008	
GIS	MB	09 Jul 2008	
CHECK	AB	23 Jul 2008	
REVIEW	AB	23 Jul 2008	

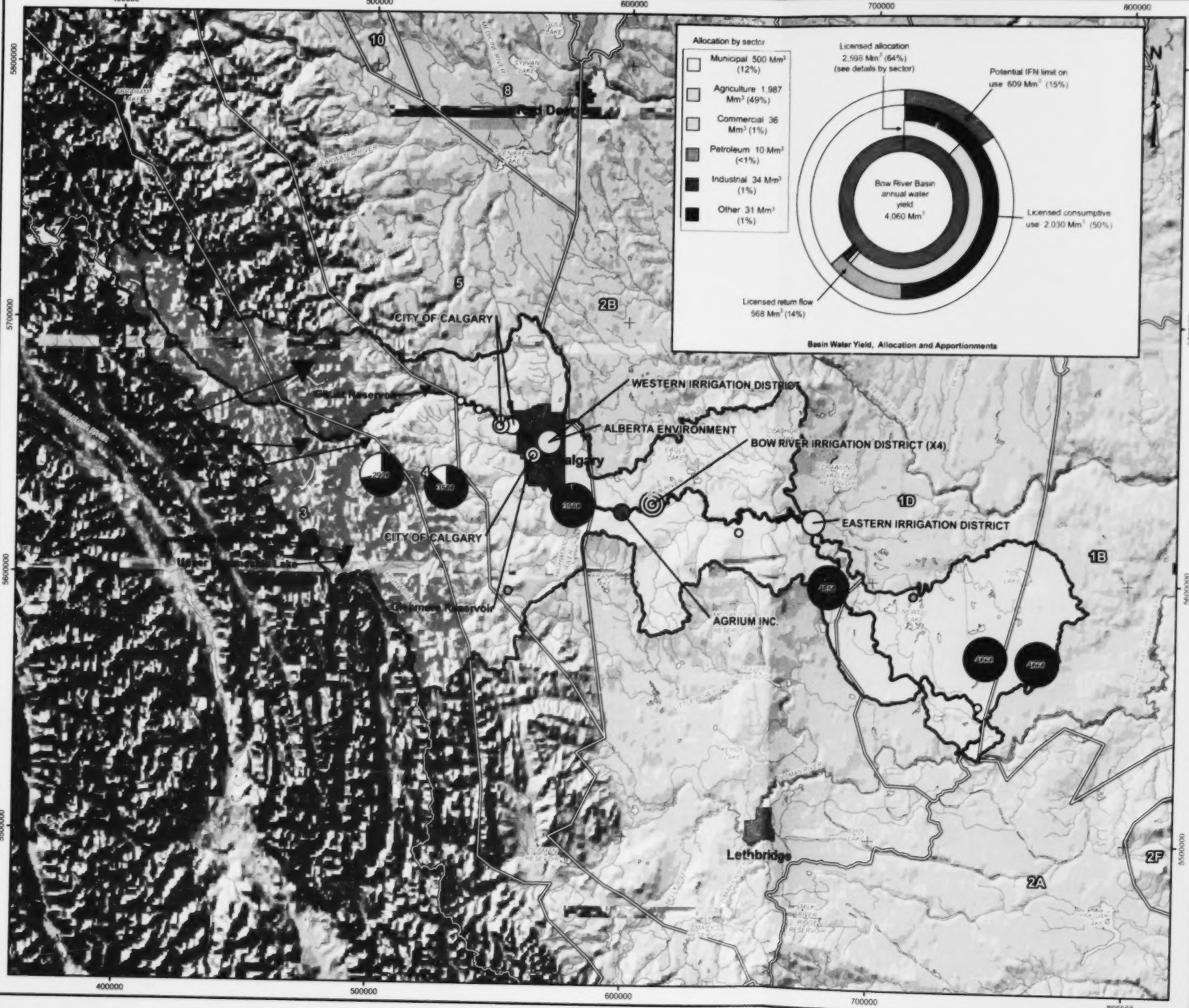
FIGURE: 6

I:\2007\07-1326\07-1326-0021\Mapping\MXD\BSA\Hydrology\OldmanBasin_Supply_Demand_Assessment_fig17.mxd

Bow River Basin

The Bow River Basin is marginally smaller than the Oldman River Basin (25,610 km² versus 28,270 km²) but produces more runoff (about 15% more). This is attributable to the Bow River Basin having a larger proportion of higher yielding, high elevation headwaters in the Rocky Mountains including the southern half of Banff National Park. Significant tributaries include the Highwood, Elbow, Kananaskis and Ghost Rivers. The City of Calgary and its one million residents is located in this basin and relies upon the waters of the Elbow and Bow Rivers for municipal water supply.

The estimated average basin supply for the Bow is 4,060 million m³. Based on the 2005 data licences totalling 2.6 billion m³ or 64% of the estimated basin water supply have been allocated. Irrigation holds the majority of licensed water in the basin (75%). Surface water allocations are not increasing since new surface water licence applications are no longer being accepted in the Bow River Basin. Actual consumption (2005 data) amounted to approximately 28% of the basin supply.



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

50 0 50

SCALE 1:1,500,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

BOW RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

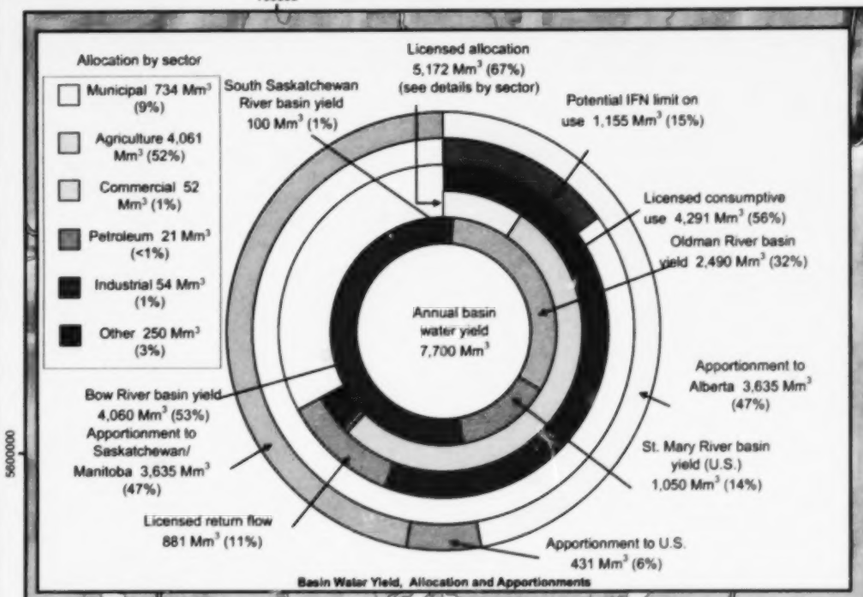
			PROJECT NO. 07-1326-0021	SCALE AS SHOWN	REV. 0
DESIGN	AB	13 Mar. 2008			
GIS	MB	07 Jul. 2008			
CHECK	AB	23 Jul. 2008			
REVIEW	AB	23 Jul. 2008			

FIGURE: 6

Lower South Saskatchewan River Basin

The South Saskatchewan River is formed by the confluence of the Oldman and Bow Rivers. The Lower South Saskatchewan Basin is defined as the local contributing area that drains to the South Saskatchewan River, below the confluence of the Bow and Oldman. (This is to make a distinction between the "South Saskatchewan River Basin" as a whole, which normally refers to the summation of the Bow, Oldman and Red Deer River Basins as well as the lower South Saskatchewan.) This sub-basin is dominated by prairie landscape and has some of Alberta's driest terrain. Incremental runoff in this basin is very little as compared to what flows in from upstream; only tributaries in the Cypress Hills generate runoff in any significant quantity.

The estimated average basin supply is about 100 million m^3. This means that close to 99% of the South Saskatchewan River at Medicine Hat is made up of the contributing flow of the Bow and Oldman Rivers. The City of Medicine Hat is the largest community in the basin with more than 60,000 people. Surface water allocations are not increasing since new surface water licence applications are no longer being accepted in the Lower South Saskatchewan River Basin.


Allocation by sector
Municipal 734 Mm³ (9%)
Agriculture 4,061 Mm³ (52%)
Commercial 52 Mm³ (1%)
Petroleum 21 Mm³ (<1%)
Industrial 54 Mm³ (1%)
Other 250 Mm³ (3%)
South Saskatchewan River basin yield 100 Mm³ (1%)
Licensed allocation 5,172 Mm³ (67%) (see details by sector)
Potential IFN limit on use 1,155 Mm³ (15%)
Licensed consumptive use 4,291 Mm³ (56%)
Oldman River basin yield 2,490 Mm³ (32%)
Annual basin water yield 7,700 Mm³
Apportionment to Alberta 3,635 Mm³ (47%)
St. Mary River basin yield (U.S.) 1,050 Mm³ (14%)
Apportionment to U.S. 431 Mm³ (6%)
Licensed return flow 881 Mm³ (11%)
Bow River basin yield 4,060 Mm³ (53%)
Apportionment to Saskatchewan/ Manitoba 3,635 Mm³ (47%)

Basin Water Yield, Allocation and Apportionments

700000

800000

5600000

5500000

1B

2B

2A

2F

7700

59

20.2

CITY OF MEDICINE HAT

N

LEGEND

- SOUTH SASKATCHEWAN RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

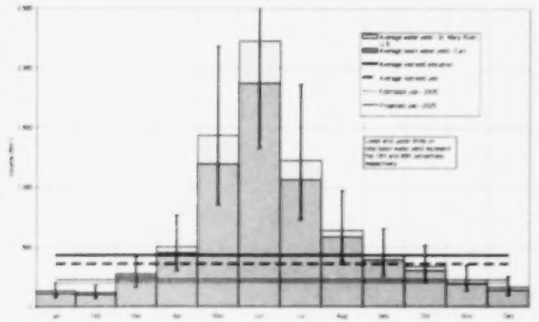
MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³
- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

20 0 20

SCALE 1:700,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

SOUTH SASKATCHEWAN RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO. 07-1326-0021			SCALE AS SHOWN	REV. 0
DESIGN	AB	13 Mar. 2008		
GIS	MB	07 Jul. 2008		
CHECK	AB	23 Jul. 2008		
REVIEW	AB	23 Jul. 2008		

FIGURE: 6

Red Deer River Basin

By area, the Red Deer River Basin is the largest sub-basin of the South Saskatchewan River (50,450 km² or 43% of the total basin area). However, the Red Deer has a relatively small mountain headwater in the front range of the Rocky Mountains and most of the basin is composed of lower runoff prairie catchments (including extremely dry areas within the eastern half of the watershed. As a result the basin yield is about 1,960 million m³ – proportionally only one-quarter the runoff yield produced by the Bow River Basin.

The City of Red Deer is the largest community and has nearly 88,000 residents. The basin has been allocated to a lesser degree than the other sub-basins of the South Saskatchewan and remains open to new applications for surface water licences. Current allocations amount to 373 million m³ or 19% of the estimated basin water supply based on the 2005 data. Actual consumption (2005 data) amounted to approximately 11% of the basin supply.

500000 600000 700000 800000

5900000 5800000 5700000 5600000

Edmonton

10 8 2C 1A 5 2B 1D 1B

ALBERTA ENVIRONMENT

NORTH RED DEER RIVER WATER SERVICES COMMISSION

NOVA CHEMICALS CORPORATION

Gleniffer Lake

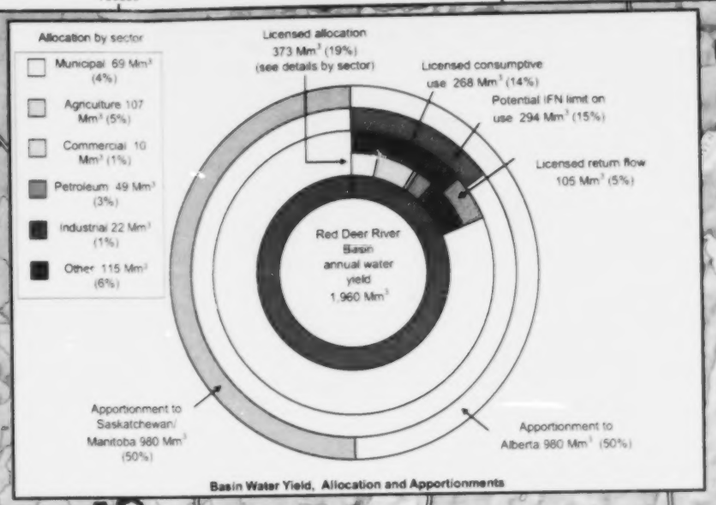
ALBERTA ENVIRONMENT

ATCO ELECTRIC LTD.

Crawling Valley Reservoir

153 602 1720 1410 1990 1990 1990

N


Allocation by sector
Municipal 69 Mm³ (4%)
Agriculture 107 Mm³ (5%)
Commercial 10 Mm³ (1%)
Petroleum 49 Mm³ (3%)
Industrial 22 Mm³ (1%)
Other 115 Mm³ (6%)
Licensed allocation 373 Mm³ (19%) (see details by sector)
Licensed consumptive use 268 Mm³ (14%)
Potential IFN limit on use 294 Mm³ (15%)
Licensed return flow 105 Mm³ (5%)
Red Deer River Basin annual water yield 1,960 Mm³
Apportionment to Saskatchewan/ Manitoba 980 Mm³ (50%)
Apportionment to Alberta 980 Mm³ (50%)

Basin Water Yield, Allocation and Apportionments

LEGEND

- RED DEER RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

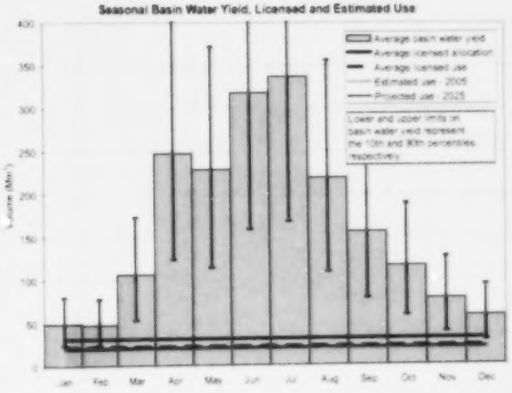
RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use


Average basin water yield
Average licensed allocation
Average licensed use
Estimated use - 2005
Projected use - 2025
Lower and upper limits on basin water yield represent the 10th and 90th percentiles respectively
Volume (Mm³)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

50 0 50

SCALE 1:1,500,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

RED DEER RIVER BASIN SUPPLY-DEMAND ASSESSMENT

PROJECT NO. 07-1326-0021			SCALE AS SHOWN REV. 0
DESIGN	AB	13 Mar. 2008	
GIS	MR	27 Jul. 2008	
CHECK	AB	29 Jul. 2008	
REVIEW	AB	29 Jul. 2008	

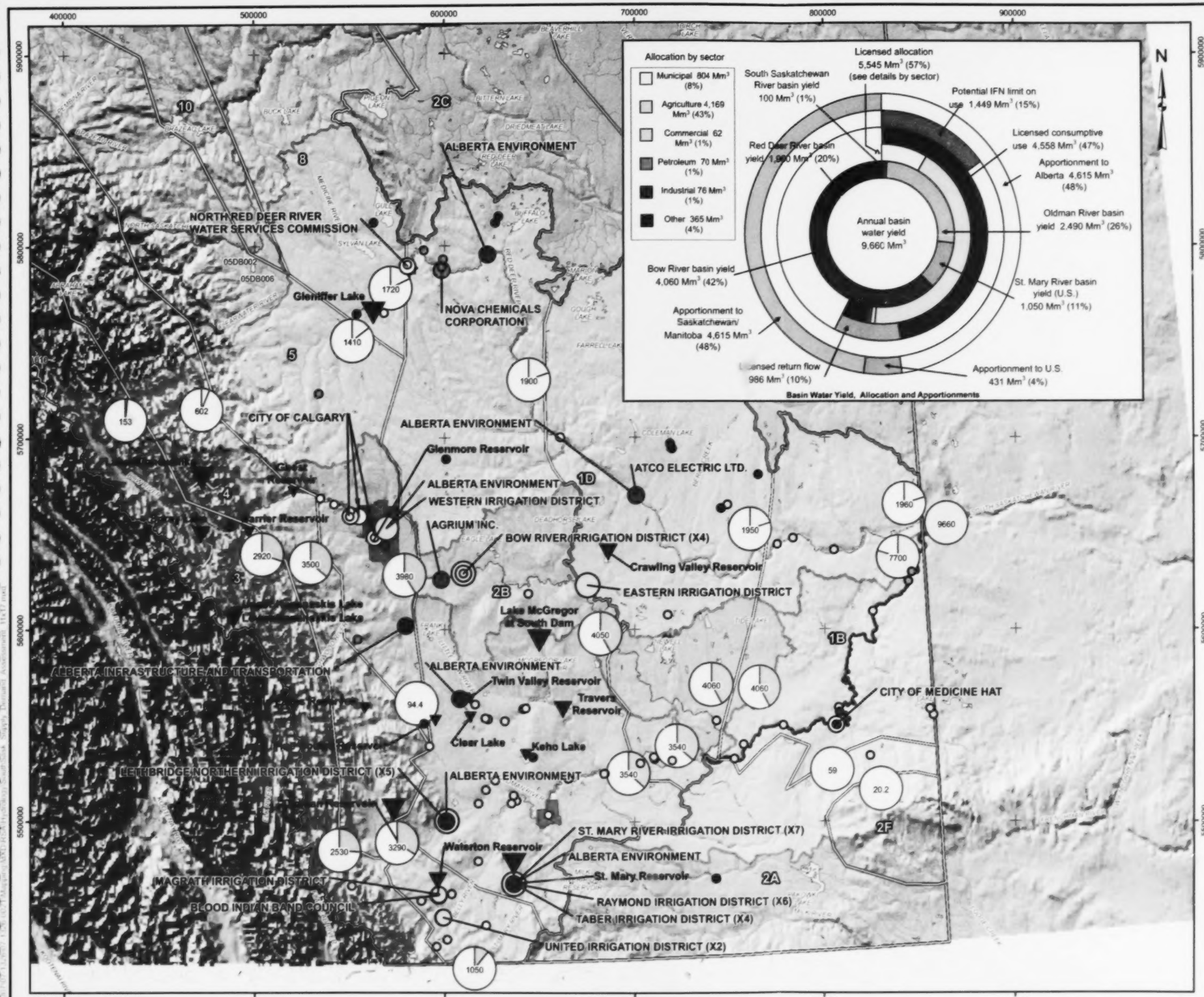
Golder Associates
Calgary, Alberta

FIGURE: 6

South Saskatchewan River Basin

The South Saskatchewan River Basin includes the Bow, Oldman and Red Deer River Basins in addition to the lower South Saskatchewan reach. The estimated average supply for the entire basin is 9,660 million m^3. Approximately 52% of the volume would be apportionable to either Saskatchewan (mostly) or the United States (9%, representing their St. Mary River entitlements). Based on the 2005 data licences totalling 5.5 billion m^3 or 57% of the estimated basin water supply have been allocated. Irrigation holds the majority of licensed water in the basin (73%) followed by municipal (14%). Actual consumption (2005 data) amounted to approximately 31% of the basin supply. A summary of each of the principal sub-basins is included below.

River Basin	Area	Average Runoff Volume
Bow	25,610 km^2 (22%)	4,060 million m^3 (42%)
Oldman	28,270 km^2 (24%)	3,540 million m^3 (37%)
Lower South Saskatchewan	12,580 km^2 (11%)	100 million m^3 (1%)
Red Deer	50,450 km^2 (43%)	1,960 million m^3 (20%)
South Saskatchewan	116,910 km^2 (100%)	9,660 million m^3 (100%)



LEGEND

- WATERCOURSE
- HYDROLOGIC REGION
- BOW RIVER WATERSHED
- OLDMAN RIVER WATERSHED
- RED DEER RIVER WATERSHED
- SOUTH SASKATCHEWAN RIVER WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

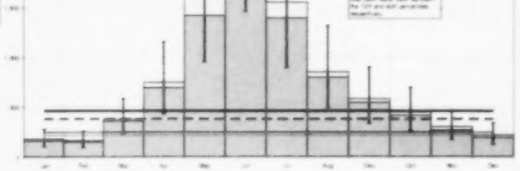
RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

4600 — PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

50 0 50

SCALE 1:2,000,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

SOUTH SASKATCHEWAN RIVER BASIN BELOW RED DEER RIVER SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO. 07-1326-0021			SCALE AS SHOWN	REV. 0
DESIGN	AB	13 Mar. 2008		
GIS	MB	09 Jul. 2008		
CHECK	AB	23 Jul. 2008		
REVIEW	AB	23 Jul. 2008		

FIGURE: 6a

Battle River Basin (including Sounding Creek Basin)

The Battle River Basin arises on the prairie landscape and is composed of two major sub-basins. The Battle River mainstem originates in central Alberta (in the region north of Red Deer and south of Edmonton) and flows east into Saskatchewan where it eventually joins the North Saskatchewan River. The second sub-basin is the Sounding Creek Basin. The hydrology of this basin is such that it is connected to downstream when the water levels in Sounding Lake are high enough to spill into Eyehill Creek (only during wet climate cycles); and further when water levels are high enough in Manito Lake, SK to spill toward the Battle River (which is rare). This sub-basin is home to some of Alberta's driest terrain. Most of the land area in both the Battle River and Sounding Creek basins is "non-effective", meaning that large areas of the landscape have poorly-defined drainage paths and only flow to downstream or into major creeks when water levels are relatively high.

The estimated average basin supply is about 293 million m^3, with 96.5% of that volume attributable to the Battle River Basin (the remainder in Sounding Creek). The cities of Wetaskiwin and Camrose are located in the western part of the Battle River Basin (populations of 11,700 and 16,500 respectively). The largest settlement in Sounding Creek Basin is the town of Provost (nearly 2,100 people) to the north. Allocations for the Battle River Basin may appear unusual (812 million m^3 in 2005) because they exceed the basin supply by close to a factor of three. This is explained by a single power plant licence that continuously diverts and returns water (withdraws water for cooling), meaning that the diversion and use is largely non-consumptive except for enhanced evaporation. Actual basin consumption (2005 data) amounted to approximately 27% of the basin supply. 50% of natural flows are apportionable to Saskatchewan.

600000 700000 800000

5900000 5800000 5700000

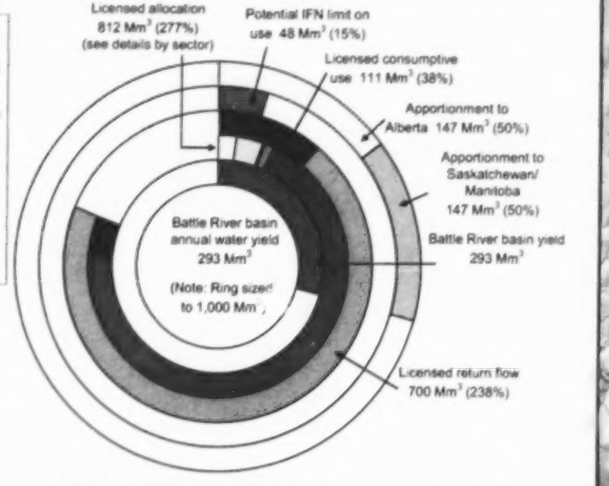
N

2C 1C 2B 1B 1A 1D 8

Rocky Mtn House

Allocation by sector

- Municipal 22 Mm³ (8%)
- Agriculture 34 Mm³ (13%)
- Commercial 3 Mm³ (1%)
- Petroleum 10 Mm³ (4%)
- Industrial 692 Mm³ (262%)
- Other 51 Mm³ (19%)


Licensed allocation 812 Mm³ (277%) (see details by sector)
Potential IFN limit on use 48 Mm³ (15%)
Licensed consumptive use 111 Mm³ (38%)
Apportionment to Alberta 147 Mm³ (50%)
Apportionment to Saskatchewan/ Manitoba 147 Mm³ (50%)
Battle River basin yield 293 Mm³
Licensed return flow 700 Mm³ (238%)
Battle River basin annual water yield 293 Mm³
(Note: Ring sized to 1,000 Mm³)

Basin Water Yield, Allocation and Apportionments

LEGEND

- BATTLE RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

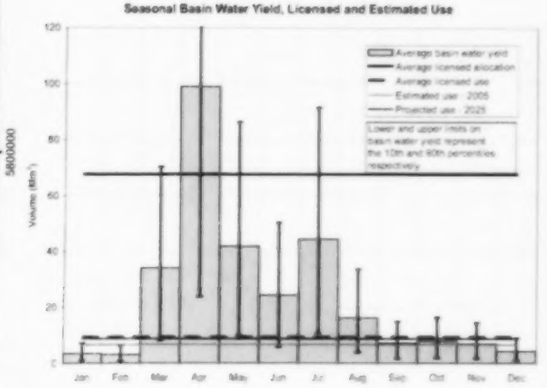
- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

40 0 40

SCALE 1:1,100,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

BATTLE RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO. 07-1326-0021			SCALE AS SHOWN REV. 0
DESIGN	AB	13 Mar 2008	
GIS	MB	07 Jul 2008	
CHECK	AB	23 Jul 2008	
REVIEW	AB	23 Jul 2008	

FIGURE: 6

North Saskatchewan River Basin

The North Saskatchewan River Basin originates in the headwaters in the Rocky Mountains including the northern portion of Banff National Park and the Columbia Icefield. The watershed drains a good portion of high alpine mountains as well as foothills landscapes, which generate many of the large flood events. Downstream, the City of Edmonton and the Capital Region is home to over one million residents that rely upon the river for municipal water supply.

The estimated average basin supply for the North Saskatchewan River is 7,530 million m^3. Apportionment to Saskatchewan represents 50% of the natural flow. Based on the 2005 data licences totalling 2.0 billion m^3 or 27% of the estimated basin water supply have been allocated for use. Thermal power production holds the majority of licensed water in the basin (79%). Though the amount allocated is relatively high, most of the water that is licensed is for uses that are relatively non-consumptive. Actual consumption (2005 data) amounted to approximately 2.6% of the basin supply.

400000 500000 600000 700000 800000

6000000 5900000 5800000 5700000

7A 10 2D 8 2C 1C 5 4 3 2B

DOW CHEMICAL CANADA INC.

WESTLOCK COUNTY

TRANSALTA UTILITIES CORPORATION (X3)

Edmonton

EPCOR POWER DEVELOPMENT CORPORATION (X2)

EPCOR POWER DEVELOPMENT CORPORATION (X3)

CITY OF EDMONTON

EPCOR POWER DEVELOPMENT CORPORATION

Brazeau Reservoir

Red Deer

Calgary

7200 7930 6570 7050 6530 5490 3590

N

LEGEND

- NORTH SASKATCHEWAN RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

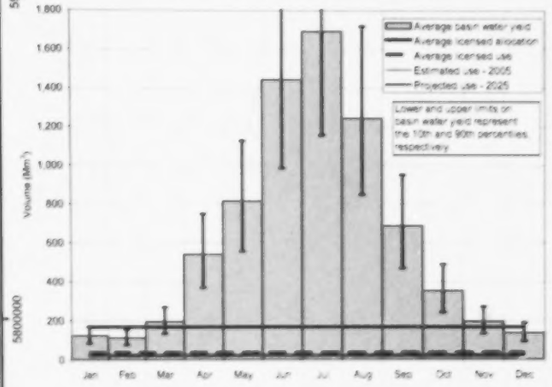
RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

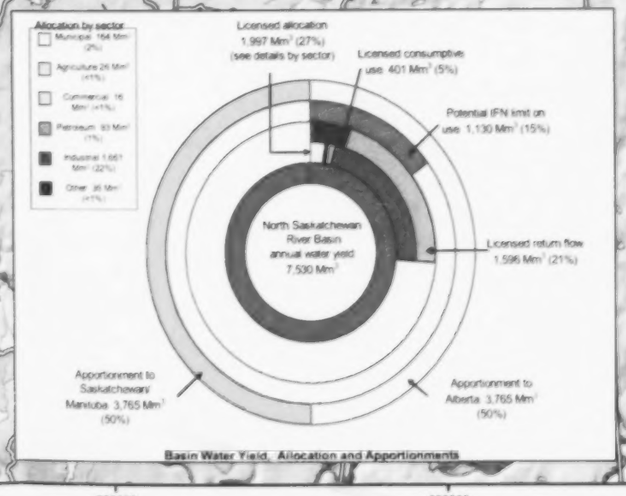
- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use




Allocation by sector
Municipal: 164 Mm³ (2%)
Agriculture 26 Mm³ (41%)
Commercial: 16 Mm³ (41%)
Petroleum: 93 Mm³ (1%)
Industrial 1,667 Mm³ (22%)
Other: 35 Mm³ (47%)
Licensed allocation 1,997 Mm³ (27%) (see details by sector)
Licensed consumptive use: 401 Mm³ (5%)
Potential IFN limit on use: 1,130 Mm³ (15%)
North Saskatchewan River Basin annual water yield 7,530 Mm³
Licensed return flow 1,596 Mm³ (21%)
Apportionment to Saskatchewan/ Manitoba: 3,765 Mm³ (50%)
Apportionment to Alberta: 3,765 Mm³ (50%)

Basin Water Yield, Allocation and Apportionments

REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

50 0 50

SCALE 1:1,750,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

NORTH SASKATCHEWAN RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO.	07-1328-0001	SCALE AS SHOWN	REV. 0
DESIGN	AB	13 Mar. 2008	
GIS	AC	28 Jul. 2008	
CHECK	AB	29 Jul. 2008	
REVIEW	AB	29 Jul. 2008	

FIGURE: 6

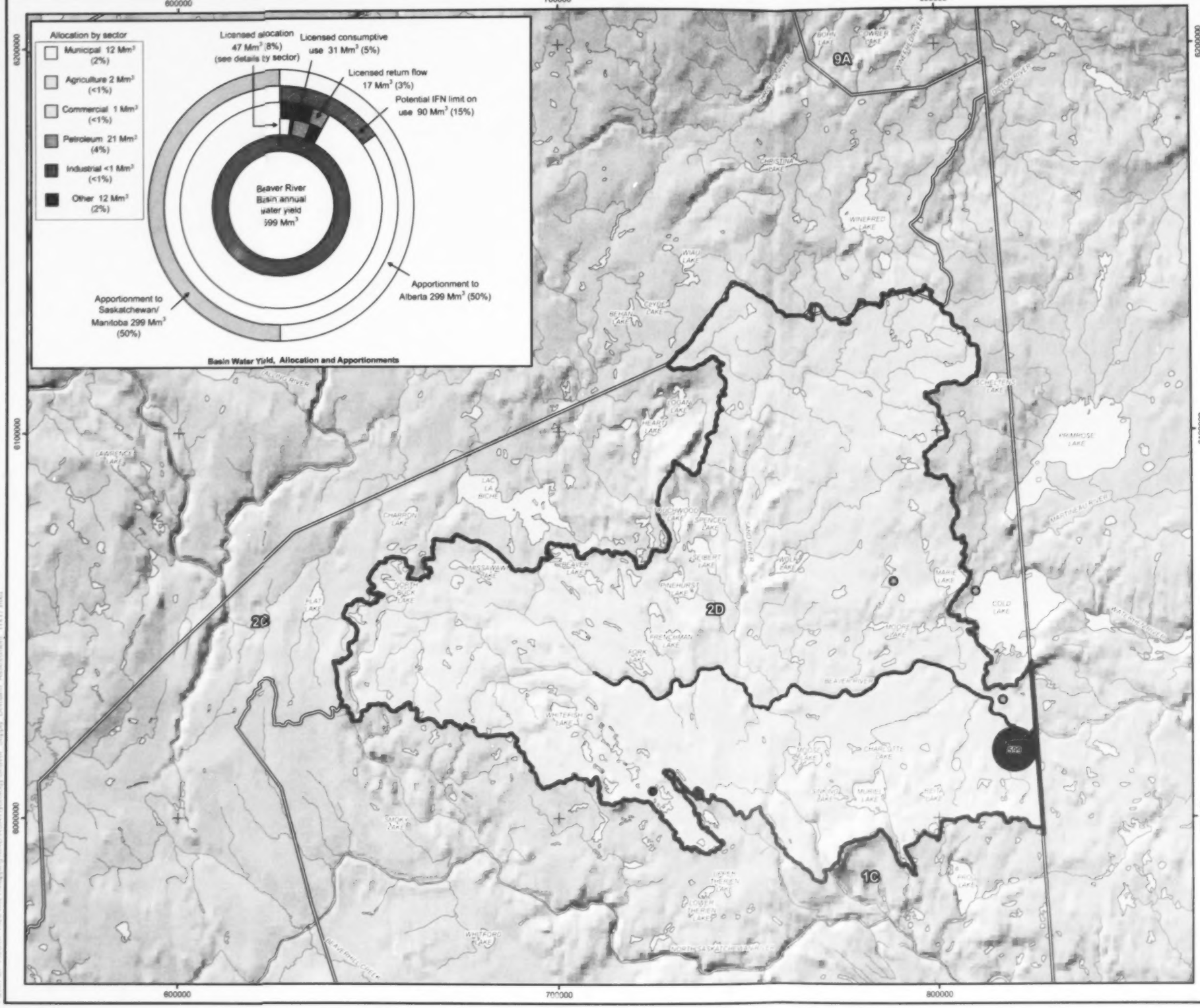
Beaver River Basin

The Beaver River Basin lies on the eastern border of Alberta with headwaters entirely in relatively low-relief prairie and boreal forest. The Cold Lake Basin is usually included with the Beaver River Basin but in this assessment the Cold Lake portion was excluded as the majority of the basin is in Saskatchewan. The two watersheds eventually join in Saskatchewan and become part of the Churchill River which drains to Hudson's Bay. Specific apportionment conditions apply to Cold Lake in addition to the more conventional 50% passing requirement for the natural flows of the Beaver River.

The Beaver River is considered to have natural flows as it is not regulated by major structures and the amount of use is relatively minor. The estimated average basin supply is about 599 million m^3 with allocations in 2005 making up approximately 7.9% of the volume. The largest allocated use is for oilfield injection (33%). (Note that total basin allocations increased by 13% between 2005 and 2007, mostly due to injection for thermal oilsands; therefore this has since increased the proportion for injection to 40% of the total.) Actual basin consumption (2005 data) amounted to approximately 2.9% of the basin supply. The largest municipality in the basin is the City of Cold Lake, with almost 13,000 residents.

Allocation by sector
Municipal 12 Mm³ (2%)
Agriculture 2 Mm³ (<1%)
Commercial 1 Mm³ (<1%)
Petroleum 21 Mm³ (4%)
Industrial <1 Mm³ (<1%)
Other 12 Mm³ (2%)
Licensed allocation 47 Mm³ (8%) (see details by sector)
Licensed consumptive use 31 Mm³ (5%)
Licensed return flow 17 Mm³ (3%)
Potential IFN limit on use 90 Mm³ (15%)
Beaver River Basin annual water yield 599 Mm³
Apportionment to Saskatchewan/ Manitoba 299 Mm³ (50%)
Apportionment to Alberta 299 Mm³ (50%)

Basin Water Yield, Allocation and Apportionments



LEGEND

- BEAVER RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- WATERBODY

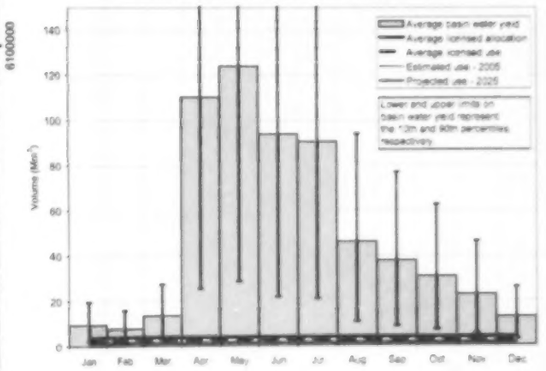
MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³
- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

40 0 40

SCALE 1:1,000,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

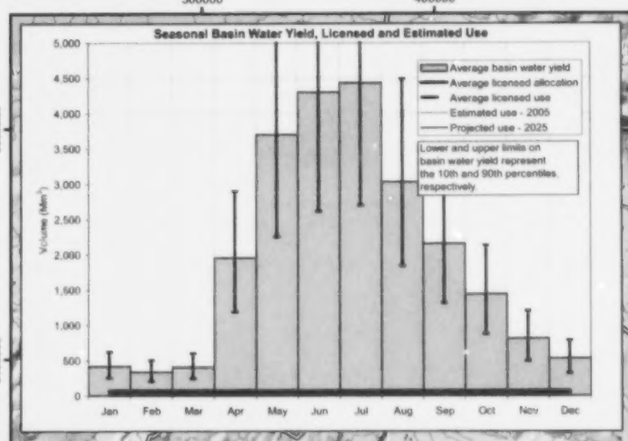
BEAVER RIVER BASIN SUPPLY-DEMAND ASSESSMENT

	PROJECT NO. 07-1326-0001		SCALE AS SHOWN	REV. 0
Golder Associates Calgary, Alberta	DESIGN	AB	13 Mar. 2006	**FIGURE: 6**
	GIS	MB	07 Jul. 2006	
	CHECK	AB	23 Jul. 2006	
	REVIEW	AB	23 Jul. 2006	

Athabasca River Basin

The Athabasca River is one of the last large rivers in Alberta that is not regulated by major structures or dams. As such, the flow in the river represents a natural flow regime. The Athabasca River Basin originates in the headwaters in the Rocky Mountains comprising most of Jasper National Park. The watershed drains a large proportion of high alpine mountains as well as foothills landscapes including the Swan Hills. Saskatchewan also provides some supply (12%) via the Clearwater River. The largest community in the basin is Fort McMurray, located just upstream of the major oil sands mines with a population exceeding 65,000.

The estimated average basin supply for the Athabasca River is 23,500 million m^3. Based on the 2005 data licences totalling 850 million m^3 or 3.6% of the estimated basin water supply have been allocated for use. Oil sands accounts for 68% of the licensed volume. Despite perceptions that water use from the river is large because of the oil sands developments, actual consumption for all users (2005 data) amounted to approximately 1.2% of average basin supply. The projected trend in water use (based on 2005 assumptions) foresaw basin consumption increasing to perhaps 2.2% by 2025. However, because the flow regime is natural and flows in the winter can be much lower than during the open water period, water use restrictions have been implemented in the lower Athabasca River reach in order to limit the amount of water that can be withdrawn during periods of low flow (*Athabasca River Water Management Framework*).



LEGEND

- ATHABASCA RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

RESERVOIR STORAGE CAPACITY OF MAJOR DAMS

- > 10 Mm³
- > 100 Mm³
- > 200 Mm³

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

75 0 75

SCALE 1:2,500,000 KILOMETRES

REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.
Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

ATHABASCA RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT No. 07-1326-0071			SCALE AS SHOWN	REV. 0
DESIGN	LC	11 Feb. 2008		
GIS	MB	09 Jul. 2008		
CHECK	AB	23 Jul. 2008		
REVIEW	AB	23 Jul. 2008		

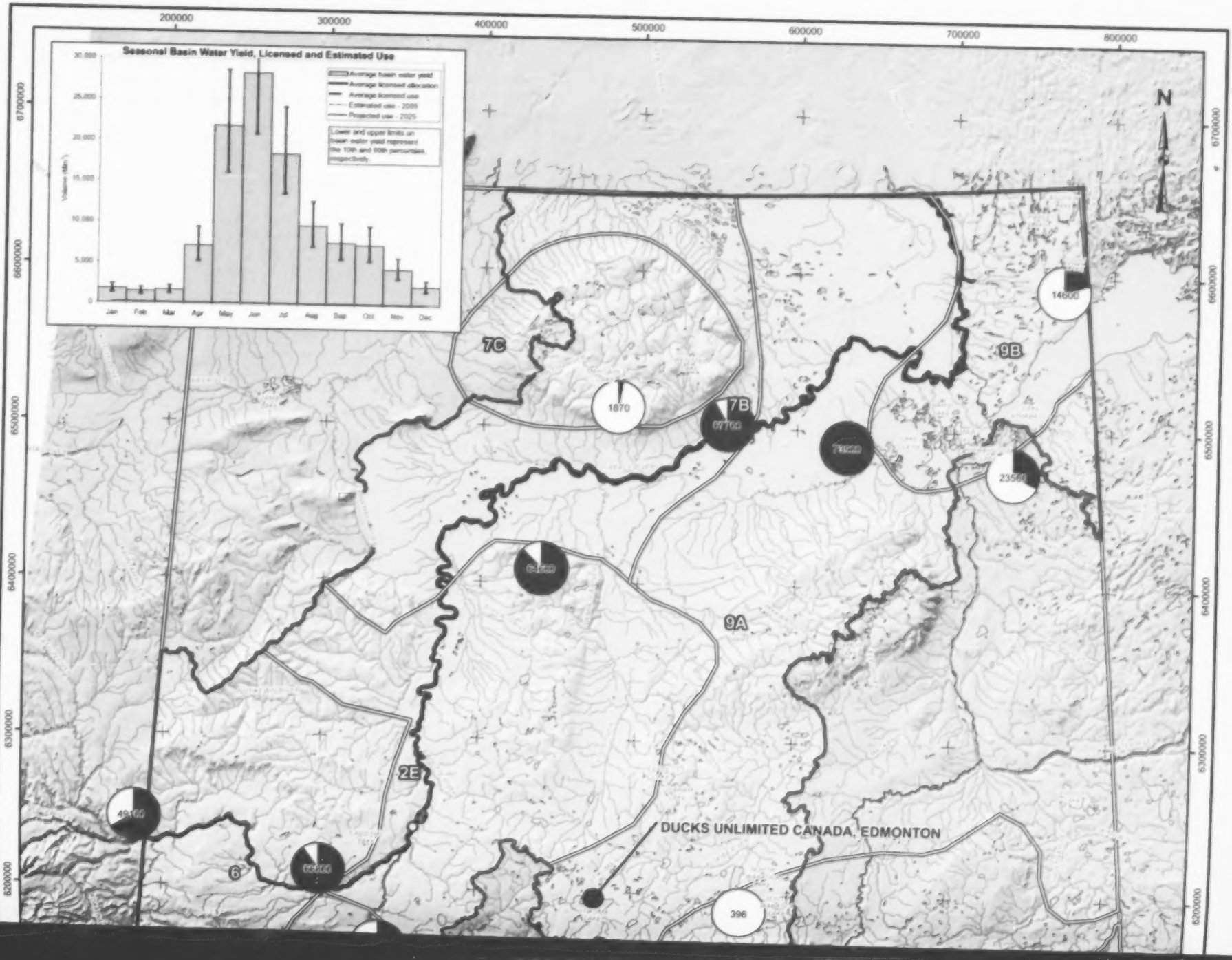
FIGURE: 6

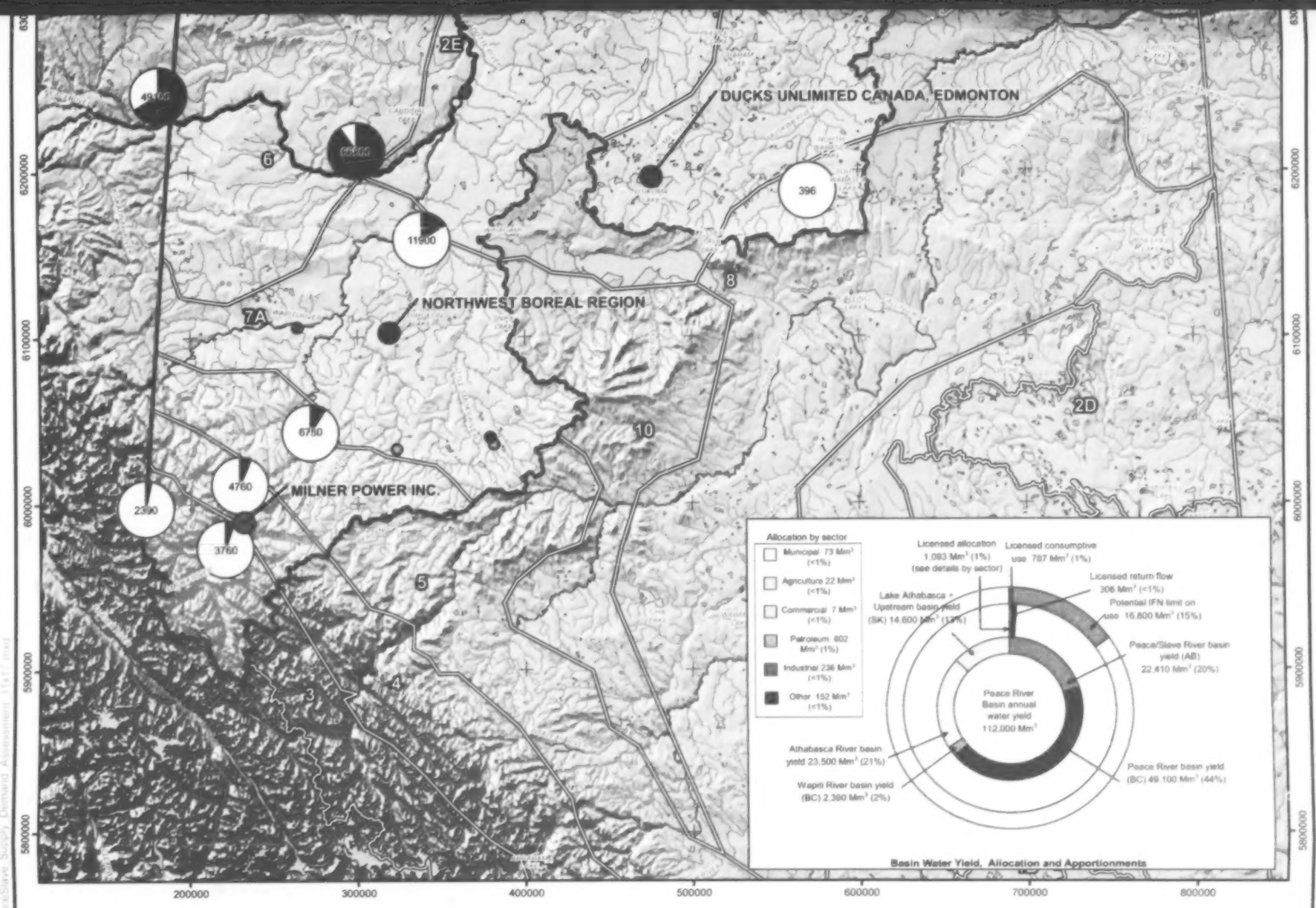
Water Supply Assessment_Sply_Demand_Assessment_11x17.mxd

Peace / Slave River Basin

The Peace River is the second-largest river in Alberta; only the Slave River which is formed by the confluence of the Peace River, Athabasca River and Lake Athabasca Basin in the Peace-Athabasca Delta is larger. The Peace headwaters are the Rocky Mountains of British Columbia (extending into Alberta) and most of the flow in the Peace River – nearly three-quarters – is already in the river by the time it crosses the AB-BC border. Contribution to the Slave River Basin from the Peace is approximately 63%. The characteristics of the Athabasca River have been discussed previously and that basin contributes 21% of the total volume to the Slave. Lake Athabasca Basin is the third major basin making up the Slave River Basin, providing 13% of average annual volume – much of it from Saskatchewan. The remaining 3% is attributed mainly to the Buffalo River Basin which also drains north to Great Slave Lake and was included with the Peace/Slave.

The Peace River Basin alone has more water supply than all the other basins in Alberta combined – some 70,200 million m^3 on an average annual basis. The estimated average basin supply for the Slave River Basin River is 112,000 million m^3. Based on 2005 data, licences totalling 1,093 million m^3 or 1.0% of the estimated basin water supply have been allocated for use. The petroleum sector accounts for 55% of the total which includes oil sands in the upstream Athabasca River Basin. Actual consumption for all users (2005 data) amounted to approximately 0.1% of average basin supply. The City of Grande Prairie is the largest community with more than 50,000 people; their water supply is derived from the Wapiti River, a tributary of the Smoky. Apportionment requirements have not yet been negotiated for the waters of the Mackenzie River Basin so have not been included in the summary.


Seasonal Basin Water Yield, Licensed and Estimated Use
Average basin water yield
Average licensed allocation
Average licensed use
Estimated use - 2005
Projected use - 2025
Lower and upper limits on basin water yield represent the 10th and 90th percentiles, respectively
Volume (dam³)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
200000
300000
400000
500000
600000
700000
800000
6700000
6600000
6500000
6400000
6300000
6200000
N
7C
9B
7B
9A
2E
6
1870
14600
23500
396
DUCKS UNLIMITED CANADA, EDMONTON



LEGEND

- PEACE / SLAVE RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- CITY
- WATERBODY

MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

- > 1 Mm³
- > 10 Mm³
- > 100 Mm³

- MUNICIPAL
- AGRICULTURE
- COMMERCIAL
- PETROLEUM
- INDUSTRIAL
- OTHER

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

75 0 75

SCALE 1:3,000,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

THE PEACE / SLAVE RIVER BASIN SUPPLY-DEMAND ASSESSMENT

REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.
Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

Golder Associates
Calgary, Alberta

PROJECT No. 07-1326-0021			SCALE AS SHOWN	REV. 0
DESIGN	LC	11 Feb. 2008		
GIS	AC	08 Jul. 2008		
CHECK	AB	23 Jul. 2008		
REVIEW	AB	23 Jul. 2008		

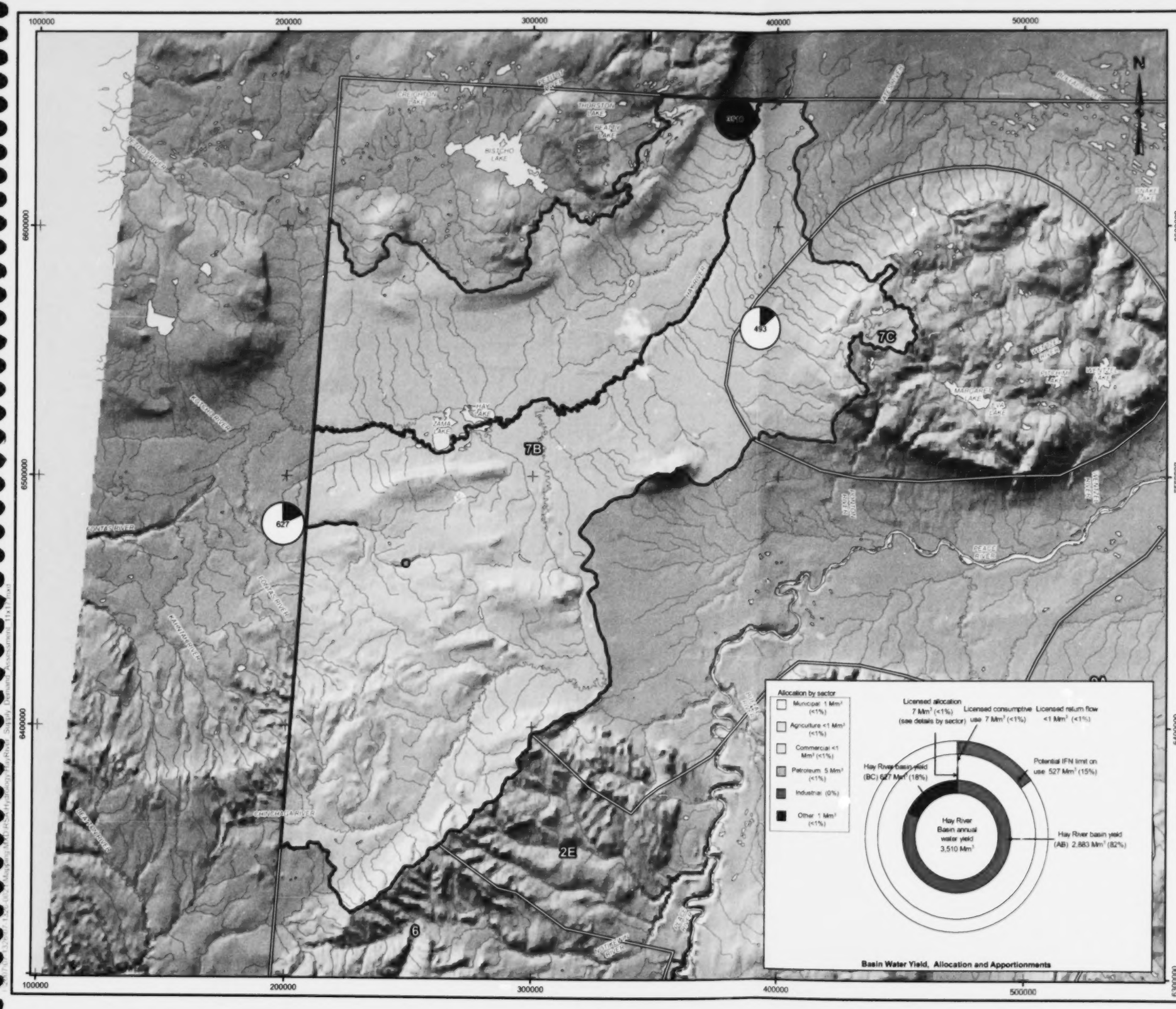
FIGURE: 6

I:\2007\07-1326\07-1326-0021\Mapping\MXD-RnA\Hydrology-PeaceSlave_Supply_Demand_Assessment_11x17.mxd

Hay River Basin

The Hay River Basin forms a part of the Mackenzie River Basin (along with the Slave River); the main difference is that the Hay River flows directly into the Mackenzie River downstream of Great Slave Lake in the NWT. The Hay River headwaters are also very different from the Peace – located in the far northwest part of Alberta and extending into British Columbia, it is principally boreal forest with some upland areas.

The Hay River Basin is estimated to have 3,510 million m^3 of water supply on an average annual basis – 18% from British Columbia. The basin is sparsely populated and licensed water use is principally for the petroleum sector (75%). The largest community is the Dene Tha' First Nation, which has more than 1,800 residents. Based on the 2005 data licences totalling 6.6 million m^3 or 0.2% of the estimated basin water supply have been allocated for use. Actual consumption for all users (2005 data) amounted to less than 0.1% of average basin supply. Apportionment requirements have not yet been negotiated for the waters of the Mackenzie River Basin so have not been included in the summary.



LEGEND

- HAY RIVER
- WATERCOURSE
- HYDROLOGIC REGION
- WATERSHED
- WATERBODY

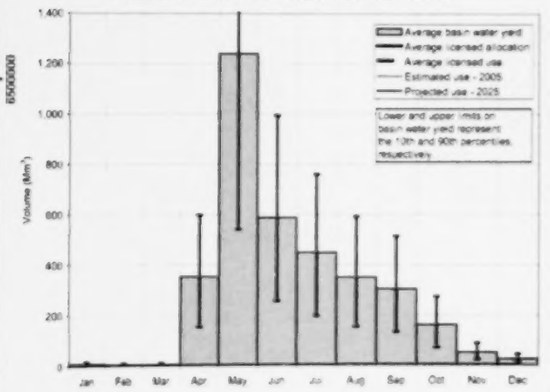
MAJOR LICENSED ALLOCATIONS (CONSUMPTIVE USE PORTION)

> 1 Mm³	MUNICIPAL
> 10 Mm³	AGRICULTURE
> 100 Mm³	COMMERCIAL
	PETROLEUM
	INDUSTRIAL
	OTHER

PROPORTION OF CUMULATIVE MEAN ANNUAL FLOW (CMAF) COMPARED WITH THAT OF MOST DOWNSTREAM LOCATION (VALUE INDICATES CMAF IN million m³)*

*Based on effective drainage area

Seasonal Basin Water Yield, Licensed and Estimated Use



Allocation by sector
Municipal: 1 Mm³ (<1%)
Agriculture: <1 Mm³ (<1%)
Commercial: <1 Mm³ (<1%)
Petroleum: 5 Mm³ (<1%)
Industrial: (0%)
Other: 1 Mm³ (<1%)
Licensed allocation: 7 Mm³ (<1%) (see details by sector)
Licensed consumptive use: 7 Mm³ (<1%)
Licensed return flow: <1 Mm³ (<1%)
Hay River basin yield (BC): 627 Mm³ (18%)
Potential IFN limit on use: 527 Mm³ (15%)
Hay River Basin annual water yield: 3,510 Mm³
Hay River basin yield (AB): 2,883 Mm³ (82%)

Basin Water Yield, Allocation and Apportionments

REFERENCE

Digital base data and digital elevation data obtained from Natural Resources Canada. Watersheds obtained from Prairie Farm Rehabilitation Administration, used under license. Hydrometric stations and hydrologic regions obtained from Alberta Environment.

Projection: Alberta 10TM False Easting 500,000 at 115° W. Datum: NAD 83

50 0 50

SCALE 1:1,500,000 KILOMETRES

PROJECT

WATER SUPPLY ASSESSMENT FOR ALBERTA

TITLE

HAY RIVER BASIN SUPPLY-DEMAND ASSESSMENT

Golder Associates
Calgary, Alberta

PROJECT NO. 07-1336-0021			SCALE AS SHOWN REV. 0
DESIGN	AB	13 Mar. 2008	
GIS	AC	07 Jul. 2008	
CHECK	AB	23 Jul. 2008	
REVIEW	AB	23 Jul. 2008	

FIGURE: 6

Liard River Basin

The Liard River Basin is a small basin in the extreme northwest corner of Alberta. Because it has few, if any permanent residents and extremely small water use – licences issued total only 50,000 m^3 (for oilfield injection) – a detailed supply-demand analysis like the other basins was not undertaken. The Liard River Basin supply was estimated to have 960 million m^3 of water supply on an average annual basis – 17% from Northwest Territories. Of further note: the basin contains the third largest lake entirely within Alberta – Bistcho Lake. Hydrologic data is otherwise extremely limited. As is also the case for the other basins of the Mackenzie River, apportionment requirements have not yet been negotiated.

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